REMARKS

Claims 15-31 are pending in this application. After claim amendments and cancellations herein, claims 22-28 will remain in this application and under consideration.

In the Office Action dated June 20, 2006, the Examiner acknowledged the election without traverse of Group II, claims 22-28, of the application and stated that claims 15-21 and 29-31 stand withdrawn from this application. In accordance with this election, Applicants have herein canceled claims 15-21 and 29-31 from this application as being drawn to non-elected inventions without prejudice to Applicants' right to reintroduce those claims at a later date or in a continuing application.

The Examiner rejected claims 22-28 under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement. According to the Examiner, claim 22 recites that the mold shell is oriented at a three-dimensional setting angle with respect to the outlet opening, but the specification at page 4, paragraph [0022] states that the adjustment of the angle sr is effected as a function of the relative densities of the nonferrous metal alloy used, the casting temperature and the rotational speed n of the vessel. The Examiner states that Applicants have failed to set forth how the angle is effected as a function of these parameters.

Applicants traverse this rejection and allege that how the angle is effected as a function of these parameters would be well known to one of ordinary skill in the art. Applicants point out to the Examiner that the specification at paragraph [0026] states that "the three-dimensional setting angles sr of the casting molds 22 are selected in such as way as to coincide with the Coriolis force vectors", and the specification at paragraph [0024] describes a Coriolis force as "the inertia force which, in addition to the guiding force and centrifugal force, acts on a body moving in a rotating system" and as being "perpendicular to the plane formed by the velocity vector and the axis of rotation". One of ordinary skill in the art certainly has (or can easily obtain) knowledge regarding Coriolis effects, as demonstrated by the printout from Wikipedia.org, a free on-line encyclopedia, attached hereto as Exhibit A.

It is, therefore, clear that different acceleration forces, such as centrifugal forces and Coriolis forces (as stated in paragraph [0026]), as well as gravity, act on the melt. It is also well known that centrifugal forces depend in particular from the rotational speed of the vessel and the mass or density of the nonferrous metal alloy used, and, when acting on a liquid, on the viscosity of the liquid, which in turn depends upon its temperature. Thus, it is well known that the flight path of the melt leaving the opening is dependent upon all of the aforementioned parameters.

In conventional casting methods, the casting mold has always been fixed radially with respect to the rotating vessel. As can be seen from the sketch attached hereto as Exhibit B (shown in a top view), in a structure such as that herein, due to the Coriolis effect, the melt would hit the inner side wall of the casting mold, and from there it would splash in different directions. In particular, when using a melt that freezes rapidly, this effect would cause a non-homogeneous filling of the casting mold. The cast product contains pores that make it necessary to further densify the cast product, i.e., that he casting must be compressed after it has been solidified, for example by a subsequently hot isostatic pressure step. During such a hot isostatic pressure step by a large isostatic pressure, the pores are squeezed.

According to the present invention, however, the casting mold is adjusted relative to the vessel with a three-dimensional setting angle, which takes into effect the Coriolis force that acts upon the melt. However, as explained above, this setting angle strongly depends upon various parameters. The setting angle must be set individually, for example, depending upon the rotational speed of the vessel, the particular metal alloy of the vessel, the temperature of the melt, etc. This can be done without undue burden by one of ordinary skill in the art by using a camera with a high-speed shutter to photograph and determine the flight path of the melt, such that the setting angle of the casting mold can be adjusted accordingly. As can be seen from the sketch attached hereto as Exhibit B, when the setting angle is adjusted in accordance with the present invention, the melt hits the base of the casting mold, such that the casting mold is filled from the base surface upward towards its opening, homogenously and without the formation of pores.

As can be seen from the sketch attached hereto as Exhibit B, the three-dimensional setting angle also has a horizontal component, which must be set in accordance with the acting

centrifugal and Coriolis forces. As one can easily envision, the flight path of the melt leaving the opening of the vessel is also influenced by gravity. However, when using high rotational speeds, the gravitational effect can be disregarded, and the vertical component of the setting angle can be set to be 90°. Accordingly, Applicants respectfully submit that claim 22 fully complies with the enablement requirement, and Applicants request that this rejection be withdrawn.

The Examiner also rejected claims 22-28 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to distinctly point out and claim the subject matter. According to the Examiner, in claim 22, it not clear what is the "three-dimensional setting angle", what axis of the mold and vertical wall of the vessel forms the angle, and what is "flow detachment in the melt". In response, Applicants have amended claim 22 to clarify its terminology. Applicants note that the term "flow detachment" results from an inaccurate translation of the original application documents, and this term has been replaced with "stall". No new matter has been added by this amendment, which is based upon the specification as filed, including at paragraphs [0005] and [0026].

The Examiner stated that there is a lack of antecedent basis for "closable cover mounted rotatably relative to the casting mold" in claim 23. In response, Applicants point out that it is not the closable cover that is claimed to be rotatably mounted relative to the casting mold but rather the vessel. Similarly, it is the vessel that is configured to receive an ingot, as recited later in that same claim. Accordingly, Applicants have amended claim 23 so as to clarify that it is the vessel that is mounted rotatably relative to the casting mold and that it is the vessel that is configured to receive an ingot of the nonferrous metal alloy corresponding to an internal diameter of the vessel. Applicants note that no new matter has been added by this amendment, which is based upon the specification as filed, including at paragraph [0028].

The Examiner stated that the meaning of "nozzle action" in claim 24 is unclear. In response, Applicants have amended claim 24 to delete the word "action" and to clarify the structure of the apparatus, namely that a distributor with a nozzle is disposed inside the vessel, the nozzle being associated with the outlet opening. Applicants note that no new matter has been added by this amendment, which is based upon Figure 2, wherein it can be seen that the channels

of the distributor 42 have a diameter that is smaller than an axial channel through which the melt is introduced. Consequently, the radial channels act as a nozzle through which the melt is accelerated, the nozzle being associated with the outlet opening 19.

The Examiner further stated that "include" in claim 27 is indefinite. In response, Applicants have amended claim 27 such that "include" has been changed to "consist of".

The Examiner further rejected claim 28 under 35 U.S.C. §112, fourth paragraph, as being of improper dependent form because it involves a method limitation in an apparatus claim. In response, Applicants have amended claim 28 such that it now reflects a limitation on an element of claim 22.

Conclusion

Reconsideration of the present application, as amended, is respectfully requested. If the Examiner has any questions or concerns regarding this response and amendment, the Examiner is respectfully requested to contact the undersigned at the telephone number set forth below.

Respectfully submitted,
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By: [signature]
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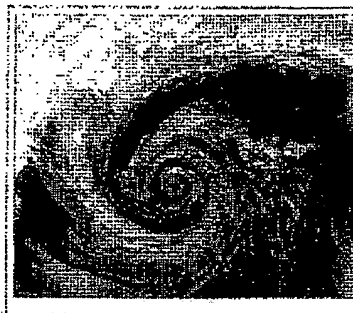
EXHIBIT A

Coriolis effect

From Wikipedia, the free encyclopedia

The **Coriolis effect** is an apparent deflection of a moving object in a rotating frame of reference.


This low pressure system over Iceland spins counter-clockwise due to balance between the Coriolis effect and the pressure gradient.

The Coriolis effect caused by the rotation of the Earth is responsible for the precession of a Foucault pendulum and for the direction of rotation of cyclones. In general, the effect deflects objects moving along the surface of the Earth to the right in the Northern hemisphere and to the left in the Southern hemisphere. As a consequence, winds around the center of a cyclone rotate counterclockwise on the northern hemisphere and clockwise on the southern hemisphere. However, contrary to popular belief, the Coriolis effect is not a determining factor in the rotation of water in toilets or bathtubs (see the *draining bathtubs/toilets* section below).

The effect is named after Gaspard-Gustave Coriolis, a French scientist, who described it in 1835, though the mathematics appeared in the tidal equations of Laplace in 1778.

Contents

Formula

The formula for the Coriolis acceleration is

$$\mathbf{a} = -2\boldsymbol{\omega} \times \mathbf{v}$$

where (here and below) $\mathbf{v}$ is the velocity of the particle in the rotating system, and $\boldsymbol{\omega}$ is the angular velocity vector (which has magnitude equal to the rotation rate and is parallel with the axis of rotation) of the rotating system. The equation may be multiplied by the mass of the relevant object to produce the Coriolis force. See Fictitious force for a derivation.

Note that this is a cross product. In non-vector terms: at a given rate of rotation of the observer, the magnitude of the Coriolis acceleration of the object will be proportional to the velocity of the object and also to the sine of the angle between the direction of movement of the object and the axis of rotation.

EXHIBIT A

The *Coriolis effect* is the behavior added by the *Coriolis acceleration*. The formula implies that the Coriolis acceleration is perpendicular both to the direction of the velocity of the moving mass and to the rotation axis. So in particular:

- if the velocity (as always, in the rotating system) is zero, the Coriolis acceleration is zero
- if the velocity is parallel to the rotation axis, the Coriolis acceleration is zero
- if the velocity is straight (perpendicularly) inward to the axis, the acceleration is in the direction of local rotation
- if the velocity is straight (perpendicularly) outward from the axis, the acceleration is against the direction of local rotation
- if the velocity is in the direction of local rotation, the acceleration is (perpendicularly) outward from the axis
- if the velocity is against the direction of local rotation, the acceleration is (perpendicularly) inward to the axis

In the formula above, the vectors are 3-d. If we are considering the simpler case of motion restricted to the surface of a rotating turntable the equation simplifies somewhat to:

$$\mathbf{a} = -2\omega\mathbf{k} \times (u, v)$$

where $\mathbf{k}$ is a unit local vertical and (u, v) is the velocity 2-d vector in the plane of the turntable.

When considering atmospheric dynamics, the Coriolis acceleration (strictly a 3-d vector in the first formula above) appears only in the horizontal equations, due to the neglect of products of small quantities and other approximations. The term that appears is then

$$-f\mathbf{k} \times (u, v)$$

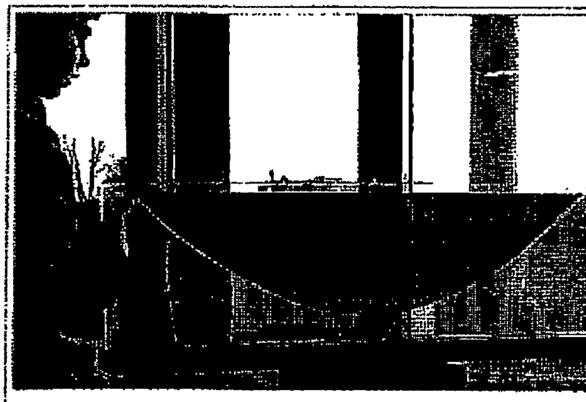
where $f = 2\omega \sin(\phi)$ (where ϕ is the latitude) is called the *Coriolis parameter* and (u, v) are the horizontal components of the velocity.

What the Coriolis effect is not

- The Coriolis effect does not depend on the curvature of the Earth, only on its rotation. However, the value of the Coriolis parameter, f, does vary with latitude, and that *is* due to the Earth's shape.
- The Coriolis effect is not the fictitious Centrifugal force given by $\omega \times (\omega \times \mathbf{r})$. However, the co-existence of Coriolis and centripetal forces makes simple explanations of the effect of Coriolis in isolation difficult.

Visualisation of the Coriolis effect

To demonstrate the Coriolis effect, a parabolic turntable can be used. On a flat turntable the centrifugal force, which always acts outwards from the rotation axis, would lead to objects being forced out off the edge. But if the surface of the turntable has the correct parabolic bowl shape, and is rotated at the correct rate, then the component of gravity tangential to the bowl surface will exactly balance the centrifugal force. This allows the Coriolis force to be displayed in isolation.


A fluid assuming a parabolic shape as it is rotating

Discs cut from cylinders of dry ice can be used as pucks, moving around almost frictionlessly over the surface of the parabolic turntable, allowing effects of Coriolis on dynamic phenomena to show themselves. To get a view of the motions as seen from a rotating point of view, a video-camera is attached to the turntable in such a way that the camera is co-rotating with the turntable.

When the fluid is rotating on a flat turntable, the surface of the fluid naturally assumes the correct parabolic shape. This fact may be exploited in order to make a parabolic turntable, by using a fluid

that sets after several hours, such as a synthetic resin.

Draining bathtubs/toilets

A popular misconception is that the Coriolis effect determines the direction in which bathtubs or toilets drain, and whether water always drains in one direction in the Northern Hemisphere, and in the other direction in the Southern Hemisphere. In reality, the Coriolis effect is a few orders of magnitude smaller than other random influences on drain direction, such as the geometry of the sink, toilet, or tub; whether it is flat or tilted; and the direction in which water was initially added to it. Note that toilets typically are designed to only flush in one rotation, by having the flush water enter at an angle.

This is less of a puzzle once one remembers that the earth revolves once per day but that a bathtub takes only minutes to drain. When the water is being drawn towards the drain, the radius with which it is spinning around it decreases, so its rate of rotation increases from the low background level to a noticeable spin in order to conserve its angular momentum (the same effect as ice skaters bringing their arms in to cause them to spin faster).

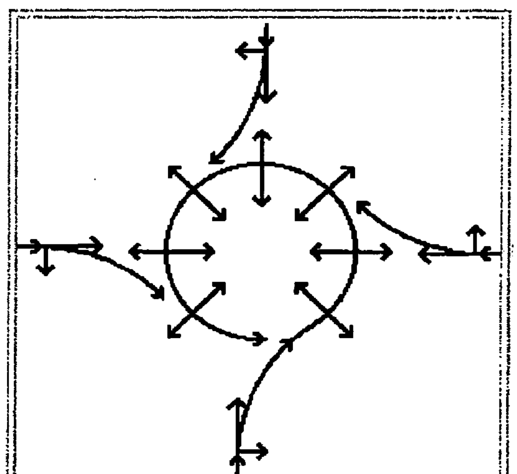
Coriolis in Meteorology

Perhaps the most important instance of the Coriolis effect is in the large scale dynamics of the oceans and the atmosphere. In meteorology, Coriolis effects tend to dominate the centrifugal effects associated with, for example, the rotation of large cyclones, because the latter are usually balanced by an ambient pressure gradient (exactly analogously to the slope on a parabolic turntable).

Flow around a low-pressure area

If a low-pressure area forms in the atmosphere, air will tend to flow in towards it, but will be deflected perpendicular to its velocity by the Coriolis acceleration. A system of equilibrium can then establish itself creating circular movement, or a cyclonic flow.

The force balance is largely between the pressure gradient force acting towards the low-pressure area and the Coriolis acceleration acting away from the center of the low pressure. Instead of flowing down the gradient, the air tends to flow perpendicular to the air-pressure gradient and forms a cyclonic flow. This is an example of a more general case of geostrophic flow in which air flows along isobars. On a non-rotating planet the air would flow along the straightest possible line, quickly leveling the air pressure. Note that the force balance is thus very different from the case of "inertial circles" (see below) which explains why mid-latitude cycles are larger by an order of magnitude than inertial circle flow would be.



Schematic representation of flow around a low-pressure area in the Northern hemisphere. The pressure gradient force is represented by blue arrows, the Coriolis acceleration (always perpendicular to the velocity) by red arrows

This pattern of deflection, and the direction of movement, is called Buys-Ballot's law. The pattern of flow is called a cyclone. In the Northern Hemisphere the direction of movement around a low-pressure area is counterclockwise. In the Southern Hemisphere, the direction of movement is clockwise because the rotational dynamics is a mirror image there. However, at high altitudes, outward-spreading air rotates in the opposite direction [1] (http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=17026) Cyclones cannot form on the equator, and they rarely travel towards the equator, because in the equatorial region the coriolis parameter is small, and exactly zero on the equator.

Inertial circles

An air or water mass moving with speed v subject only to the Coriolis force travels in a circular trajectory called an 'inertial circle'. Since the force is directed

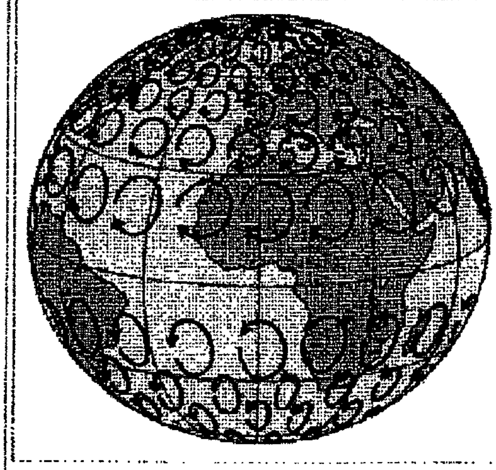
EXHIBIT A

at right angles to the motion of the particle, it will move with a constant speed, and perform a complete circle with frequency f. The magnitude of the Coriolis force also determines the radius of this circle:

$$R = v/f.$$

On the Earth, a typical mid-latitude value for f is 10^{-4}; hence for a typical atmospheric speed of 10 m/s the radius is 100 km, with a period of about 14 hours. In the ocean, where a typical speed is closer to 10 cm/s, the radius of an inertial circle is 1 km. These inertial circles are clockwise in the northern hemisphere (where trajectories are bent to the right) and anti-clockwise in the southern hemisphere.

If the rotating system is a parabolic turntable, then f is constant and the trajectories are exact circles. On a rotating planet, f varies with latitude and the paths of particles do not form exact circles. Since the parameter f varies as the sine of the latitude, the oscillations associated with a given speed are smallest at the poles (latitude = $\pm 90^\circ$), and would increase indefinitely at the equator, except the dynamics ceases to apply close to the equator.



Schematic representation of inertial circles of air masses in the absence of other forces, calculated for a wind speed of approximately 50 to 70 m/s. Note that the rotation is exactly opposite that normally experienced with air masses in weather systems around depressions.

The dynamics of inertial circles are different from those of mid-latitude cyclones. In the latter case, the Coriolis force (directed outward) is in an approximate balance with the pressure gradient force (directed inward), a situation known as geostrophic balance. In particular, cyclones rotate in the opposite direction as inertial circles.

Length scales and the Rossby Number

The time, space and velocity scales are important in determining the importance of the Coriolis effect. Whether rotation is important in a system can be determined by its Rossby number, which is the ratio of the velocity of a system to the product of the Coriolis parameter, and the lengthscale of the motion:

$$Ro = \frac{U}{fL}.$$

A small Rossby number signifies a system which is strongly affected by rotation, and a large Rossby number signifies a system in which rotation is unimportant. An atmospheric system moving at $U = 10$m/s occupying a spatial distance of $L=1000$km, has a Rossby number

$$Ro = \frac{10}{10^{-4} \times 1000 \times 10^3} = 0.1$$

A man playing catch may throw the ball at $U=30$m/s in a garden of length $L=50$m. The Rossby number in this case would be

$$Ro = \frac{30}{10^{-4} \times 50} = 6000.$$

Needless to say, one does not worry about which hemisphere one is in when playing catch in the garden. However, an unguided missile obeys exactly the same physics as a baseball, but may travel far enough and be in the air long enough to notice the effect of Coriolis. Long range shells landed close to, but to the right of where they were aimed until this was noted (or left if they were fired in the southern hemisphere, though most were not).

The Rossby number can also tell us about the bathtub. If the lengthscale of the tub is about $L=1$m, and the water moves towards the drain at about 60cm/s, then the Rossby number is

$$Ro = \frac{0.6}{10^{-4} \times 1} = 6000.$$

Thus, the bathtub is, in terms of scales, much like a game of catch, and rotation is likely to be unimportant.

However, if the experiment is very carefully controlled to remove all other forces from the system, rotation can play a role in bathtub dynamics. An article in the British "Journal of Fluid Mechanics" in the 1930's describes this. The key is to put a few drops of ink into the bathtub water, and observing when the ink stops swirling, meaning the viscosity of the water has dissipated its initial vorticity (or curl; i.e. $\nabla \times U = 0$) then, if the plug is extracted ever so slowly so as not to introduce any additional vorticity, then the tub will empty with a counterclockwise swirl in England.

Terrestrial effects summarized

A summary of Coriolis effects on the Earth's surface. Note that some of these assume that we are considering a "2-d" velocity, in the plane tangential to the planet's surface (if this restriction is removed, the latitude dependence of the strength of the Coriolis effect disappears).

- the magnitude of the Coriolis effect changes with the latitude and the speed of the air (and water).
- the Coriolis effect is greatest in polar regions where the surface of the Earth is at right angles to the axis of rotation.
- the Coriolis effect decreases nearer the equator because the surface of the Earth is parallel to the axis of rotation.
- the Coriolis effect causes air (and water) masses to turn right in the northern hemisphere and causes air (and water) masses to turn left in the southern hemisphere.
- the Coriolis effect gives rise to geostrophic winds and currents.
- a geostropic motion is one in which a pressure gradient force is balanced by an equal and opposite Coriolis force.
- the effect works in opposite directions in the two hemispheres.

The Coriolis effect strongly affects the large-scale atmospheric circulation, leading to the Hadley, Ferrel, and Polar cells. In the oceans, Coriolis is responsible for the propagation of Kelvin waves and the establishment of the Sverdrup balance.

Because the Earth is almost a sphere and not flat, there are also components of the Coriolis effect that are not in the plane tangential to the Earth's surface. The following effects are greatest at low latitudes near the equator; and may require precise instruments to detect, since they are quite small:

- an object dropped from a great height will be deflected slightly east
- an object launched straight upward will be deflected slightly west
- an object travelling eastward will be deflected slightly up
- an object travelling westward will be deflected slightly down

Coriolis Elsewhere

Coriolis flow meter

A practical application of the Coriolis effect is the mass flow meter, an instrument that measures the mass flow rate of a fluid through a tube. The operating principle was introduced in 1977 by Micro Motion Inc. Simple flow meters measure volume flow rate, which is proportional to mass flow rate only when the density of the fluid is constant. If the fluid has varying density, or contains bubbles, then the volume flow rate multiplied by the density is not an accurate measure of the mass flow rate. The Coriolis mass flow meter operating principle essentially involves rotation, though not through a full circle. It works by inducing a vibration of the tube through which the fluid passes, and subsequently monitoring and analysing the inertial effects that occur in response to the combination of the induced vibration and the mass flow.

Molecular physics

In polyatomic molecules, the molecule motion can be described by a rigid body rotation and internal vibration of atoms about their equilibrium position. As a result of the vibrations of the atoms, the atoms are in motion relative to the rotating coordinate system of the molecule. Coriolis effects will therefore be present and will cause the atoms to move in a direction perpendicular to the original oscillations. This leads to a mixing in molecular spectra between the rotational and vibrational levels.

Ballistics

The Coriolis effects became important in external ballistics for calculating the trajectories of very long-range artillery shells. The most famous historical example was the Paris gun, used by the Germans during World War I to bombard Paris from a range of about 120 km.

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Footnotes

External links

- The definition of the Coriolis effect from the Glossary of Meteorology (http://amsglossary.allenpress.com/glossary/search?id=coriolis-force1)
- The Coriolis Effect (http://met.no/english/topics/nomek_2005/coriolis.pdf) PDF-file. 17 pages. A general discussion by Anders Persson of various aspects of the coriolis effect, including Foucault's Pendulum and Taylor columns.
- Anders Persson The Coriolis Effect: Four centuries of conflict between common sense and mathematics, Part I: A history to 1885 (http://www.meteohistory.org/2005historyofmeteorology2/01persson.pdf) History of Meteorology 2 (2005)
- Coriolis Force (http://scienceworld.wolfram.com/physics/CoriolisForce.html) - from ScienceWorld
- *The Coriolis Effect: An Introduction. Details of the causes of prevailing wind patterns.* (http://teacherresourceexchange.org/science/coriolis/) Targeted towards ages 5 to 18.
- *Coriolis Effect and Drains* (http://www.newton.dep.anl.gov/askasci/phy00/phy00733.htm) An article from the NEWTON web site hosted by the Argonne National Laboratory.
- *Do bathtubs drain counterclockwise in the Northern Hemisphere?* (http://www.straightdope.com/classics/a1_161.html) by Cecil Adams.
- *Bad Coriolis.* (http://www.ems.psu.edu/~fraser/Bad/BadCoriolis.html) An article uncovering misinformation about the Coriolis effect. By Alistair B. Fraser, Emeritus Professor of Meteorology at Pennsylvania State University

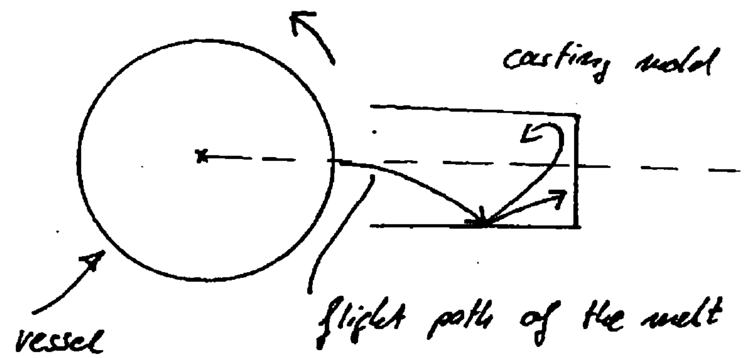
Retrieved from "http://en.wikipedia.org/wiki/Coriolis_effect"

Categories: Classical mechanics | Dynamical systems | Force | Atmospheric dynamics | Physical phenomena

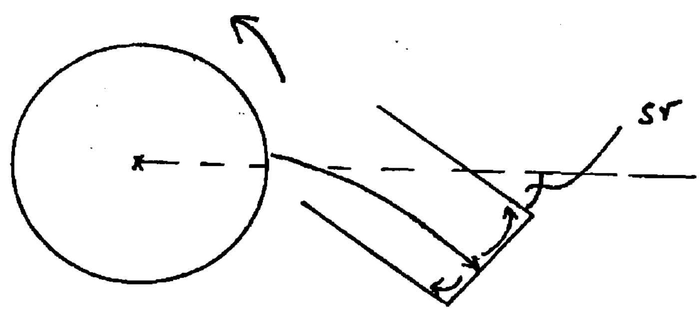
Wikimedia Commons has media related to:
Coriolis effect

EXHIBIT B

Prior Art



Invention



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